SECTION 4. STREAM, WETLAND, AND FOREST REHABILITATION OPPORTUNITIES

This section describes rehabilitation opportunities associated with the stream valley and riparian corridor of Watts Branch and its tributaries. The primary focus of the rehabilitation discussion is on opportunities for stream rehabilitation and stabilization to improve habitat and reduce channel erosion. Concept designs for specific reaches were developed as part of the Phase II work and are described below. In addition, reforestation and wetland management plans were developed to supplement and enhance the existing forest and wetland resources within the Watts Branch riparian corridor.

4.1 Stream Rehabilitation Opportunities

A total of 62 stream reach locations were identified as being in need of stabilization or rehabilitation, as part of the RSAT assessment (see Figure 4.1). Where appropriate, adjacent locations were combined to form a single rehabilitation site. Using this approach, 35 stream reach rehabilitation sites were identified. This section presents an inventory and describes the ranking system used to document which stream rehabilitation projects have the highest priority for implementation. Lastly, this section presents the list of the highest priority sites.

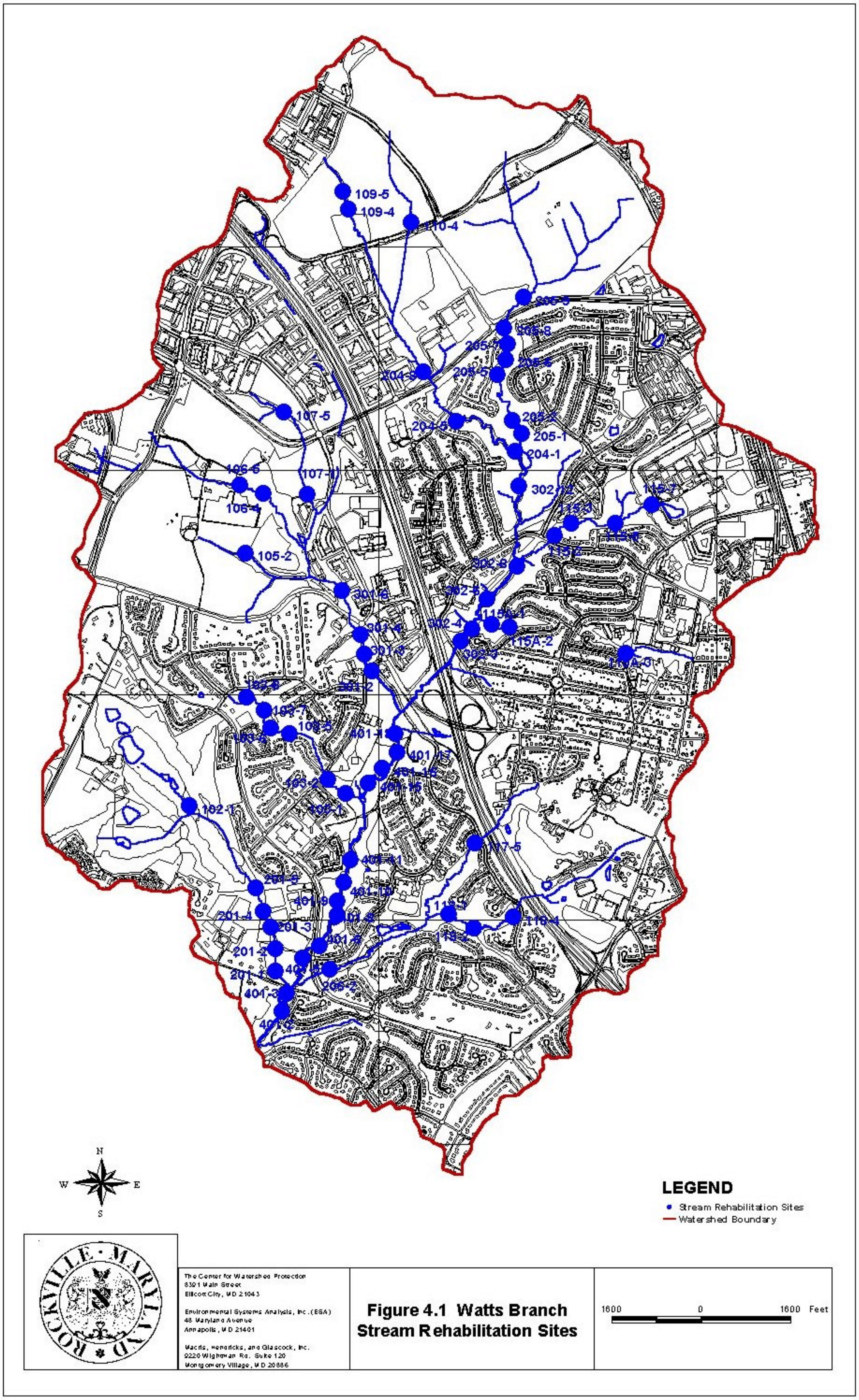
Stream rehabilitation involves the recovery of eco-system functions and processes in a disturbed habitat. Rehabilitation, however, does not necessarily reestablish the predisturbance condition, but does involve establishing hydrologically stable landscapes that support the natural ecosystem mosaic (USDA, 1998). Stream rehabilitation can cover a broad range of practices including riparian reforestation, wetland creation and enhancement, habitat creation, and streambank stabilization. For this phase of the Watts Branch study, the stream rehabilitation focus is primarily on opportunities for streambank stabilization using both “hard” or structural practices and bioengineering practices (practices that employ live vegetation). Wetland enhancement and forest conservation recommendations were also developed, but in less detail than the stream rehabilitation concepts.

There are a suite of streambank stabilization measures that can be implemented depending on the site-specific characteristics. Practices that have been recommended as part of this study include bioengineering, imbricated riprap, boulder revetment, root wads, and bank shaping. A brief description of these practices is provided below:

Bioengineering–practices that involve the use of plant material in the form of live woody cuttings or poles of readily sprouting species (e.g., willows), which are inserted deep into the bank or anchored in various other ways (USDA, 1998). Bioengineering is a more flexible technique that allows the stream channel to adjust to the hydrologic and sediment regime of the stream.

Boulder revetment–structural practice comprised of placed boulders at the toe of banks to provide protection against undercutting that may result in bank failure. This practice is usually combined with other practices that address stabilization or protection of the upper bank.

Figure 4.1 Watts Branch Stream Restoration Sites



Imbricated riprap–structural practice comprised of placed rock (usually large and flat) that is rigid and robust to protect the entire vertical extent of the stream bank from erosion or potential failure. Imbricated riprap is often utilized in areas where eroding banks threaten private property or infrastructure and there is little space available for stream bank re-grading and the use of bioengineering techniques or where these techniques would not provide a sufficient level of protection.

Root wads–practice using large logs with intact roots that are placed in trenches cut into the banks so that the root wads face upstream to dissipate flow velocities. These bank protection measures are rigid, however, they also provide dynamic near-bank habitat (USDA, 1998).

Bank shaping–practice that involves re-grading the stream bank to a stable angle and geometry and the utilization of vegetative plantings to stabilize the stream bank and prevent future bank erosion.

4.1.1 Description of Stream Rehabilitation Inventory

A stream rehabilitation inventory was incorporated into the RSAT field study to identify reaches of stream that show signs of degradation and instability. The RSAT assessment identified all significant erosion areas within the limits of the investigation. It is important to note that not all stream channels were field investigated due to the limitations of the RSAT technique as described in Section 2.2.2. Consequently, some erosion areas may exist on non-RSAT stream reaches.

The Stream Rehabilitation Inventory also reflected a certain amount of judgement on the part of the consultants, who walked and took observations along the entire length of every stream. Streams are not homogenous, and conditions can change from stable to eroded over a short distance. Therefore, stream rehabilitation sites were selected based on average conditions in a stream reach. Since streams are dynamic systems, responding to both natural and man-made influences, no single rating system or series of measurements can categorize a stream as stable or unstable in the absence of professional judgment.

"Best professional judgment" of the severity of erosion is based on several criteria including bank height, bank slope, bank material, erosion pattern, and presence or absence of roots/riparian vegetation. Conditions were compared relative to each stream, as well as to urban streams in general. The RSAT scoring system was used at riffles located approximately 400 feet apart, and tends to represent conditions at and immediately adjacent to the RSAT point. RSAT score for channel stability was considered, but there was no "cut-off" score to determine inclusion on the rehabilitation list.

There are more detailed and measurable methods to evaluate stream erosion and to select sites in need of stabilization, including bank pins and scour chains to detect bank and bed erosion, respectively, and the establishment and monitoring of permanent cross-sections to determine any and all changes in cross-sectional geometry. Typically, several years of data (5 or more years) are required for these methods to document changes caused by erosion. Due to the amount of effort required, they are only used over long periods, typically for individual reaches as part of a research effort. In the future, the City expects to use the geomorphic assessment data from this study as a baseline for measuring long-term erosion/deposition changes to the channel geometry at the same locations.

The reaches needing rehabilitation were prioritized, with the highest priority sites targeted for conceptual-level design. The RSAT stations were used as the initial inventory locations; however, stream reaches in need of rehabilitation often extended over consecutive RSAT stations. Site characteristics such as length of impacted reach and adjacent vegetation were also documented. The following provides a description of the major categories used in the inventory to document conditions at each location:

Overall RSAT Score: Overall RSAT score for each rehabilitation site. For rehabilitation sites that are comprised of adjacent RSAT stations, this figure represents the average of two or more stations.

RSAT Score for Channel Stability: RSAT Channel stability score for each rehabilitation site. For rehabilitation sites that are comprised of adjacent RSAT stations, this figure represents the average of two or more stations.

Length of Study Area: "Study Area" is defined as the length of stream which will be studied for rehabilitation design purposes. A distance of 400 feet has been assigned as the study length for each RSAT station because this is the distance between RSAT points. Consecutive RSAT stations in need of rehabilitation will have study lengths equal to (# of consecutive data points) x (400).

Length of Treatment Area: "Length of Treatment Area" (LTA) is defined as that portion of the study area which will likely receive rehabilitation treatment. Because designs for rehabilitation have not been developed for these areas, it is estimated that 60% of the study area is in need of rehabilitation. Therefore, LTA is equivalent to (study area) x (0.60).

Adjacent Vegetation Type: Refers to vegetation types adjacent to rehabilitation sites; described as "forest," "shrub," "turf," or combinations thereof.

Access for Construction: Access is described as "good," "fair," or "poor" based on land ownership of the access and treatment areas, and whether sensitive natural resources such as forests, streams, or wetlands would be affected during access or construction work..

Affected Facilities and Resources: Refers to public and private resources and facilities such as utility lines, pathways, roadways, and recreational features which are in jeopardy due to existing stream conditions (erosion).

Potential Rehabilitation Techniques: Potential rehabilitation techniques are provided for each treatment area. Techniques are based on notes and photos taken during RSAT field work, as well as the Rosgen stream type and adjacent vegetation. These are preliminary suggestions only, and are subject to change based on further investigation and/or design.

Estimate of Cost per Linear Foot for Construction: Estimated costs are based on "potential rehabilitation techniques" listed for each treatment area according to the following scale:

Bioengineering	$50/l.f.
Boulder Revetment	$100/l.f.
Root Wad Revetment	$125/l.f.
Imbricated Rip-Rap	$150/l.f.
Grade Control	add $25/l.f.
Channel Realignment	add $50/l.f.
Remove Existing Structures	add $50/l.f.
First Order Stream	add $0
Second Order Stream	add $0
*Third Order Stream	add $25/l.f.
*Fourth Order Stream	add $50/l.f.

* Increases in cost are due to larger stream size, which influences grading and material costs, as well as care of water costs.

Estimate of Total Cost for Construction: Total construction costs are determined by multiplying the LTA by the estimated construction costs per linear foot. Since both the LTA and construction costs are estimates, these figures should be considered preliminary. Actual treatment lengths, techniques, and costs will vary. For rehabilitation sites comprised of consecutive RSAT stations, the estimate of total construction costs is based on the average linear foot of construction costs multiplied by the LTA.

Table 4.1 provides a summary of the rehabilitation inventory, providing quantitative and qualitative observations that were made during field and office analysis.

Table 4.1 Watts Branch RSAT Project: Stream Rehabilitation Inventory

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Length of Study Area	Length of Treatment Area (ft.) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
102-1	5	24	≤400'	240	turf	poor* (golf course)		bioengineering approach: bank shaping, plant banks with woody vegetation	$50	$12,000
103-1 103-2	3.5 (avg.)	27 (avg.)	≤800'	480	turf with shrubs	good		bioengineering approach: minor bank shaping, toe protection, plant banks with woody vegetation	$50	$24,000
103-5	2 (avg.)	18.25 (avg.)	≤1,600'	960	forest	fair		bank shaping with root wads, imbricated rip-rap, or boulder revetment	$168.75 (avg.)	$162,000
103-6					forest		swim club (pool)	imbricated rip-rap or boulder revetment; grade control		
103-7					turf with shrub		gas utility	imbricated rip-rap, or boulder revetment; grade control		
103-8					forest			severe bank erosion; root wads, imbricated rip-rap, boulder revetment, grade control		
105-2	2	19	≤400'	240	forest	poor* (Thomas farm)		severe bank erosion; root wads, imbricated rip rap, boulder revetment	$150	$36,000
106-4 106-5	2 (avg.)	27.5 (avg.)	≤800'	480	forest	poor* (Thomas farm)		eroded meander; bank shaping, toe protection, boulder revetment	$100	$48,000

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Area (ft)	Length of Treatment Area (ft.) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
107-1	3	20	≤400	240	shrub	poor* (Thomas farm)		incised channel; bank shaping, root wads, boulder revetment	$150	$36,000
107-5	4	21	≤400	240	turf	fair		incised channel; bank shaping, remove ford crossing	$75	$18,000
109-4 109-5	3.5 (avg.)	17.5 (avg.)	≤800	480	forest, shrub& turf	poor* (King farm)		tortuous, eroded meander; channel relocation, boulder revetment root wads	$162.50 (avg.)	$78,000
					forest			toe protection using boulder revetment; remove existing 24" culvert		
110-4	9	27	≤400	240	turf	poor* (King farm)		gabion revetment; remove gabion, shape and plant banks with woody vegetation	$100	$24,000
115-2 115-3	3 (avg.)	28 (avg.)	≤800	480	forest	fair		erosion upstream of culvert; channel realignment, boulder revetment, root wads	$175	$84,000
								severe erosion; grade control, stabilization may not be feasible		

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Area (ft)	Length of Treatment Area (ft.) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
115-5	4	23	≤400	240	forest	fair		minor erosion threatening residential property; boulder revetment	$100	$24,000
115-7	3	21	≤400	240	forest	fair		severe erosion; root wads, boulder revetment	$125	$30,000
115a-1	3.66 (avg.)	22 (avg.)	≤1200	720	forest	fair	sanitary sewer utility	toe protection using root wads, boulder revetment	$117 (avg.)	$84,240
115a-2								erosion from fallen tree; remove tree, toe protection, boulder revetment, root wads		
115a-3								minor erosion on intermittent channel; boulder revetment		
117-5	2	16	≤400	240	forest	fair		incised, severely eroded; grade control, toe protection, boulder revetment	$125	$30,000
118-1	5	34	≤400	240	forest	poor		debris jam reducing channel capacity; remove blockage	$50	$12,000
118-4	3	10	≤400	240	forest	fair		bank shaping, boulder revetment, grade control	$125	$30,000

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Area (ft)	Length of Treatment Area (ft) (SAx.60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
201-1					forest			eroded meander; imbricated rip-rap, root wads, boulder revetment		
201-2					forest			discrete erosion along meander; spot treatment using imbricated rip-rap, boulder revetment; remove in-stream debris		
201-3	4.6 (avg.)	25.8 (avg.)	≤2,000	1200	forest	fair		discrete erosion; spot treatment using imbricated rip-rap, boulder revetment; grade control	$130 (avg.)	$156,000
201-4					forest			erosion downstream of gabion check dam; imbricated rip-rap, boulder revetment, grade control		
201-5					turf			discrete erosion, channel blockage; spot treatment using bioengineering, remove debris jam		
204-1	4	34	≤400	240	forest	fair	sanitary sewer utility	eroded sewer line crossing; re-encase sewer utility, minor channel relocation, grade control	$175* (not incl. sewer re-encasement)	$42,000
204-5	5	33	≤400	240	forest	good		minor bank erosion; toe protection using boulder revetment	$100	$24,000
204-8	9	37	≤400	240	forest	good		gabion revetment; stable reach; investigate removing gabion	$200	$48,000

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Length (ft)	Length of TreatmentArea (ft) (SAx.60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
205-1 205-2	5 (avg.)	37 (avg.)	≤800	480	forest	fair		continuous erosion; bank shaping, boulder revetment, root wads	$88 (avg.)	$42,240
								discrete areas of erosion; spot treatments using bioengineering		
205-5 205-6 205-7	4 (avg.)	23 (avg.)	≤1200	720	forest	fair		minor bank erosion; bank plantings	$75	$54,000
								debris jam causing siltation of riffle; remove blockage		
								erosion increasing downstream; grade control, boulder revetment		
205-8	non-rsat	non-rsat	≤400	240			outfall	failed reno-mattress & plunge pool; rehabilitate structure	N/A	N/A
205-9	6	23	≤400	240	shrub & grass	good		erosion along meander; bioengineering approach, willow posting	$50	$12,000
206-2	3	22	≤400	240	forest	fair		incised, eroded reach; grade control, boulder revetment, root wad	$175	$42,000

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Length (ft)	Length of Treatment Area (ft) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
301-2 301-3 301-4	4.3 (avg.)	25.7 (avg.)	≤1200	720	forest	fair		minor erosion; bioengineering approach	$100 (avg.)	$72,00
							gas utility	continuous erosion; boulder revetment, root wads		
					turf		sewer utility	continuous erosion; bioengineering approach		
301-6	7	34	≤400	240	forest	fair		severe erosion below station; debris jam; remove blockage, imbricated rip-rap	$225	$54,000
302-3 302-4	4 (avg.)	24.5 (avg.)	≤800	480	forest	fair	sewer manhole	erosion along meander; debris jam; remove blockage, boulder revetment, root wads	$200	$96,000
302-6	8	32	≤400	240	forest	fair		grade control required for tributary	$50	$12,000
302-8	4	29	≤400	240	forest	fair		debris jam; erosion in utility ROW; remove blockage, bioengineering approach in ROW	$125	$30,000

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Length (ft)	Length of Treatment Area (ft) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
302-12	5	38	≤400	240	forest	fair		erosion along meander; toe protection, boulder revetment	$125	$30,000
401-2	3.5 (avg.)	25 (avg.)	≤800	480	forest	fair		severe erosion; imbricated rip-rap	$225	$108,240
401-3							unidentified utility	in-stream blockage, toe erosion; remove blockage, boulder revetment, root wads		
401-5	4.5 (avg.)	22 (avg.)	≤800	480	mix	fair		debris jam; remove blockage	$100	$48,000
401-6					forest			continuous erosion; bank shaping, bioengineering approach		
401-8	4.5 (avg.)	26.75 (avg.)	≤1600	960	forest	fair		continuous erosion; toe protection, bioengineering approach	$144 (avg.)	$138,240
401-9								erosion along toe of banks; toe protection, boulder revetment		
401-10							gas utility	toe protection using boulder revetment, root wads, grade bank to allow access to floodplain		
401-11							bridge footer (toe path)	address erosion at bridge footer; boulder revetment		

Rehab Site #	Rsat Score: Channel Stability	Overall Rsat Score	Total Study Length (ft)	Length of Treatment Area (ft) (SA x .60)	Adjacent Vegetation Type	Access for Construction	Affected Facilities and Resources	Potential Rehabilitation Techniques	Estimated Cost per Linear Foot (Construction)	Project Cost Estimate (Construction Only)
401-15	3.66 (avg.)	26 (avg.)	≤1200	720	turf	fair		erosion along meander; bioengineering approach	$131 (avg.)	$94,320
401-16					turf			erosion from outfall; bioengineering approach		
401-17					forest			debris jam; continuous erosion; remove blockage, boulder revetment,		
401-18	non-rsat	non-rsat			forest			eroded, incised channel; bank shaping, toe protection, boulder revetment, root wads		

4.1.2 Ranking System

Two separate ranking systems were developed to evaluate and prioritize individual stream rehabilitation sites that were identified in the field. The first system was developed by ESA, based on the field information that was collected as part of the RSAT analysis. The second system was developed by the City and Watts Branch Partnership as a potential variation from the original ESA approach.

The first ranking system used criteria and assigned weighting values based on best professional judgement, input from the Watts Branch Partnership, City staff and experience. The following discussion provides the rationale for selecting the factors and assigning the weights for the first ranking system.

The output of the stream rehabilitation ranking system produced an overall score for each stream rehabilitation site based on a 100 point numeric scale, whereby the site with the highest overall score represents the best opportunity for stream rehabilitation.

ESA prepared the first ranking system, which was more technical and encompassed all known factors. The overall score is derived from the sum of individual scores based upon the following five evaluation categories:

- Channel condition
- The extent of the problem
- Public and community benefits
- Feasibility and access
- Project cost

The selection of stream rehabilitation sites also considers future activities in the watershed, especially stormwater retrofits, stream buffer enhancement, and other restoration and rehabilitation projects. These considerations were used to further prioritize the sites which receive the highest scores from the ranking system (in other words, a "second tier" ranking process) to favor those which are or will be located in proximity to other watershed rehabilitation projects. Table 4.2 presents the criteria and associated points.

Table 4.2 Watts Branch Stream Rehabilitation Ranking System by ESA

1.	**CHANNEL CONDITION** (**35%** of total score)		**Score**
1a.	RSAT Score for Channel Stability at the rehabilitation Site:	9-11	2
		6-8	5
		3-5	10
		0-2	15

1b.	RSAT Score for Channel Stability immediately upstream of the rehabilitation site:	9-11	10
		6-8	6
		3-5	4
		0-2	1

1c.	Overall RSAT score upstream of rehabilitation site (Avg. of 3 sta. above) (If no station above, then score 5):	42-56	10
		26-41	6
		16-25	4
		0-15	1

2. EXTENT OF PROBLEM (**30%** of total score)

2a. Length of treatment area:

<250	linear feet	2
251-500	linear feet	4
501-750	linear feet	6
751-1000	linear feet	8
>1000	linear feet	10

2b. Stream size at rehabilitation site:

First Order	1
Second Order	2
Third Order	3
Fourth Order	5

2c.	Bank erosion threatens meadow/grassed area	1
	Erosion threatens forested area (non-wetland)	3
	Erosion threatens scrub/shrub wetland	3
	Erosion threatens forested wetland	5

2d.	No maintained resources threatened	0
	Erosion threatens recreational feature (path, ballfield, etc.)	2
	Erosion threatens storm drain outfall or utility feature (gas, water, sewer, etc.)	4
	Erosion threatens private property/structure	6
	Erosion threatens transportation infrastructure (road, bridge, culvert)	10

3.	**LAND OWNERSHIP AND ACCESS** (**20%**of total score)	
3a.	Rehabilitation site on privately owned land	1
	Rehabilitation site includes both public and private land	5
	Rehabilitation site on publicly owned land or within public drainage easement	10
3b.	Access for Construction:	
	Poor access requires crossing of private property	0
	Fair access is through non-City easement and/or impacts sensitive natural resources	5
	Good access entirely on public land or City easement and requires no impacts to sensitive natural resources	10
4.	**PROJECT COST** (**15%** of total score)	
	Cost per linear foot of rehabilitation (construction only):	
	>$175 linear foot	1
	$125-175 linear foot	5
	$75-124 linear foot	10
	<$ 75 linear foot	15
	TOTAL POSSIBLE SCORE	**100**

Upon request of the Partnership, City staff developed a second ranking system that simplified the selection variables for stream rehabilitation. The revised system focused on issues that most concerned the Partnership members: length and severity of erosion, ownership of the stream and forest/tree impacts from the construction. These variables indicated both the relative need for stream stabilization and the most significant costs and difficulties associated with a proposed project. They also showed the widest range among the ranking criteria. The relative point award distribution for each of the four categories for the second ranking system is presented in Table 4.3. Table 4.4 presents the raw data that were used to determine the relative site rankings under the simplified stream project ranking approach. An April 19, 2000 memorandum was prepared by City staff and provided to the Partnership describing the simplified stream project ranking system. This memorandum is listed in Appendix F and is part of the overall project record.

Table 4.3 Watts Branch Revised Stream Rehabilitation Ranking System by City and Partnership

1.	**LENGTH OF CHANNEL EROSION** (**25%** of total score)		**Score**
		400'	5
		800'	10
		1200'	15
		1600'	20
		2000'	25
2.	**RSAT CHANNEL STABILITY** (**25%** of total score)		
		5-11.0	6.25
		4.0-4.9	12.5
		3.0-3.9	18.75
		0.0-2.9	25.0
3.	**LAND OWNERSHIP** (**25%**of total score)		
		Private 0	
		Both	15
		Public	25
4.	**FOREST IMPACTS FROM CONSTRUCTION** (**25%** of total score)		
		>400'	0
		100-399'	10
		1-99'	20
		0 (No Impacts)	25
	TOTAL POSSIBLE SCORE		**100**

A summary of the results of the first (ESA) and second (revised) ranking systems are provided below.

4.1.3 Priority of Sites Based on Ranking System

Table 4.5 and 4.6 present the results of the ESA and revised City rehabilitation ranking analyses, respectively. The ranking system was applied to each of the 35 rehabilitation sites (the reader is reminded that the 62 RSAT stations identified as needing stream stabilization were combined into 35 rehabilitation sites due to the proximity of several stations to one another), based on a spreadsheet analysis that used the data collected as part of the field inventory and office analysis (Table 4.1). Sites have been sorted from highest to lowest score; highest score represents the greatest potential benefit from stream rehabilitation.

Table 4.4 Simplified Stream Project Ranking System Raw Data

Project ID	Length of Project (ft)	RSAT Channel Stability	Ownership	Forest Impacts from Construction (ft)
102-1	400	5	private	0
103-1&2	800	3.5	public	0
103-5 to 8	1600	2	both	0
105-2	400	2	private	30
106-4&5	800	2	private	600
107-1	400	3	private	0
107-5	400	4	public	50
109-4&5	800	3.5	private	0
110-4	400	9	private	0
115-2&3	800	3	public	600
115-5	400	4	public	350
115-7	400	3	public	40
115a-1 to 3	1200	3.66	public	100
117-5	400	2	public	75
118-1	400	5	public	150
118-4	400	3	public	50
201-1 to 5	2000	4.6	private	300
204-1	400	4	public	250
204-5	400	5	public	0
204-8	400	9	public	100
205-1 & 2	800	5	public	500
205-5 to 7	1200	4	public	400
205-8	400	-	public	400
205-9	400	6	private	0
206-2	400	3	public	100
301-2 to 4	1200	4.3	public	0
301-6	400	7	both	0
302-3 & 4	800	4	public	0
302-6	400	8	public	0
302-8	400	4	public	0
302-12	400	5	public	700
401-2 & 3	800	3.5	public	500
401-5 & 6	800	4.5	public	0
401-8 to 11	1600	4.5	public	450
401-15 to 18	1600	3.66	public	0
Total	24800			

Table 4.5 Stream Rehabilitation Sites: Descending Order Ranking by ESA

Rehab Site	Ranking Criteria										
	1a.	**1b.**	**1c.**	**2a.**	**2b.**	**2c.**	**2d.**	**3a.**	**3b.**	**4.**	**Total**
103-1/2	10	10	4	4	1	1	0	10	10	15	**65**
301-2/4	10	6	6	6	3	3	4	10	5	10	**63**
401-8/11	10	4	6	8	4	3	4	10	5	5	**59**
115a-1/3	10	4	5	6	1	3	4	10	5	10	**58**
205-5/7	10	6	4	6	2	3	0	10	5	10	**56**
205-1/2	10	6	6	4	2	3	0	10	5	10	**56**
401-5/6	10	4	6	4	4	3	0	10	5	10	**56**
401-15/18	10	6	6	6	4	3	0	10	5	5	**55**
302-6	5	4	6	2	3	3	0	10	5	15	**54**
204-5	10	6	6	2	2	3	0	10	5	10	**54**
103-5/8	15	1	4	8	1	3	6	5	5	5	**53**
302-3/4	10	6	6	4	3	3	4	10	5	1	**52**
204-1	10	4	6	2	2	3	4	10	5	5	**51**
117-5	15	4	5	2	1	3	0	10	5	5	**50**
302-12	10	6	6	2	3	3	0	10	5	5	**50**
115-5	10	4	4	2	1	3	0	10	5	10	**49**
201-1/5	10	6	6	10	2	3	0	1	5	5	**48**
302-8	10	4	6	2	3	3	0	10	5	5	**48**
115-2/3	10	6	4	4	1	3	0	10	5	5	**48**
107-5	10	4	4	2	1	1	0	10	5	10	**47**
401-2/3	10	1	4	4	4	3	4	10	5	1	**46**
118-1	10	1	4	2	1	3	0	10	0	15	**46**
106-4/5	15	6	6	4	1	3	0	1	0	10	**46**
206-2	10	4	4	2	2	3	0	10	5	5	**45**
115-7	10	4	5	2	1	3	0	10	5	5	**45**
118-4	10	4	5	2	1	3	0	10	5	5	**45**
105-2	15	10	6	2	1	3	0	1	0	5	**43**
102-1	10	4	5	2	1	1	0	1	0	15	**39**
205-9	5	4	4	2	2	1	0	1	5	15	**39**
204-8	2	6	6	2	2	3	0	10	5	1	**37**
301-6	5	5	5	2	3	3	0	5	5	1	**34**
109-4/5	10	4	5	4	1	3	0	1	0	5	**33**
107-1	10	4	6	2	1	3	0	1	0	5	**32**
110-4	2	4	4	2	1	1	0	1	0	10	**25**
205-8	NA			2	2		0	10	5	--	**NA**

NA = non-RSAT site

Table 4.6 Stream Rehabilitation Sites: Revised Descending Order Point Ranking by City and Partnership

Project ID	Length of Project	RSAT Channel Stability	Ownership	Forest Impacts from Construction	Total Score
401-15 to 18	20	18.75	25	25	88.75
103-5 to 8	20	25	15	25	85
103-1&2	10	18.75	25	25	78.75
301-2 to 4	15	12.5	25	25	77.5
117-5	5	25	25	20	75
302-3 & 4	10	12.5	25	25	72.5
401-5 & 6	10	12.5	25	25	72.5
115-7	5	18.75	25	20	68.75
115a-1 to 3	15	18.75	25	10	68.75
118-4	5	18.75	25	20	68.75
302-8	5	12.5	25	25	67.5
107-5	5	12.5	25	20	62.5
204-5	5	6.25	25	25	61.25
302-6	5	6.25	25	25	61.25
206-2	5	18.75	25	10	58.75
401-8 to 11	20	12.5	25	0	57.5
109-4&5	10	18.75	0	25	53.75
115-2&3	10	18.75	25	0	53.75
401-2 & 3	10	18.75	25	0	53.75
115-5	5	12.5	25	10	52.5
204-1	5	12.5	25	10	52.5
205-5 to 7	15	12.5	25	0	52.5
301-6	5	6.25	15	25	51.25
105-2	5	25	0	20	50
107-1	5	18.75	0	25	48.75
201-1 to 5	25	12.5	0	10	47.5
118-1	5	6.25	25	10	46.25
204-8	5	6.25	25	10	46.25
205-1 & 2	10	6.25	25	0	41.25
205-9	5	6.5	0	25	36.5
102-1	5	6.25	0	25	36.25
110-4	5	6.25	0	25	36.25
302-12	5	6.25	25	0	36.25
106-4&5	10	25	0	0	35
205-8	5	-	25	0	-

The City's revised stream rehabilitation ranking system yielded similar results to the ESA system. Although projects moved up and down in the ranking order, it was generally not significant and most of the same sites qualified as "high priority" for rehabilitation. This revised City approach was useful, in that it quantified expected tree/forest impacts for access and construction, which were not explicitly defined under the ESA approach.

The highest scoring stream rehabilitation sites were mapped on a subwatershed basis to determine which specific subwatersheds of Watts Branch are likely to be a priority for implementation (see Section 5 for a detailed discussion). Based on the results of the ranking analysis and discussion between the City, Partnership, and the Center team, the 35 sites were broken into 2 tiers. Initially, 11 of the 35 sites were selected for further investigation (i.e., development of conceptual designs). However, to minimize negative implementation factors such as construction access and other disruptions/disturbances, an additional grouping of sites occurred to include some lower ranking sites in the top tier. The end result of this grouping was that 14 total sites (comprising nine separate projects) were targeted for further investigation. Table 4.7 presents a summary of the nine recommended projects and associated stream reaches.

Table 4.7 Stream Rehabilitation Projects

Project Number	Stream Station(s) Comprising Project	Description of Project
1	103-1 to 103-2 & 401-15 to 401-18	minor bank shaping, toe protection, plant banks with woody vegetation
2	301-2 to 301-4	boulder revetment, root wads, bioengineering
3	401-8 to 401-11	toe protection, boulder revetment, root wads
4	115a-1 to 115a-3, 302-6 , 302-8 & 302-3 to 302-4	toe protection, boulder revetment, root wads
5	205-5 to 205-8	bank plantings, removal of debris jams, boulder revetment
6	205-1 to 205-2, 302-12, & 204-1	bank shaping, boulder revetment, root wads, toe protection
7	401-5 to 401-6 & 401-2 to 401-3	imbricated riprap, boulder revetment, root wads, bank shaping
8	204-5	toe protection, boulder revetments
9	103-5 to 103-8	bank shaping, imbricated riprap, root wads, boulder revetment

4.1.4 Recommended Stream Restoration Projects

Detailed concept design drawings of the nine projects were prepared as part of the Phase II tasks. The plans and supporting details contain information such as plan view of the proposed rehabilitation components, limits of disturbance, construction and maintenance access, utility protection (if necessary), impacts to natural resources, and estimates of number of trees to be removed. The design information was presented to the Watts Branch Partnership and displayed at the two open houses by the City. Due to the size of the plans, they are not included in this report; however, the City maintains copies of the relevant information (see Appendix F for a listing of project support information not presented in this report). The major types of rehabilitation measures proposed are described below, followed by a description of each project.

Since stream erosion is an ongoing process, the actual extent of disturbance and techniques shown in the concepts will be adjusted to reflect conditions at the time of final design. The City may also conduct restoration of other reaches within the Watts Branch watershed should critical problems or opportunities arise outside of the proposed work areas. Also, if proposed SWM projects are not able to be implemented, downstream reaches may require additional or more extensive stream restoration than originally recommended in this study. DPW will re-evaluate these reaches during final design stage.

Neighborhood coordination will be done during final design stage, and should include notification to nearby residents, adjacent property owners, civic/homeowners' associations, local schools and garden clubs, affected parks users and environmental interests. Signs at proposed access and work areas should be posted to help alert the community of the coming project.

The City Forester will work closely with DPW to improve tree preservation on stream restoration projects. The Forest Conservation Plans will include standard practices such as root pruning and placing wood chips in construction areas within the critical root zones of trees to be saved. The City Forester has also designated potential reforestation/afforestation areas on some stream restoration concept plans that will be considered at final design.

Stream Stabilization Structure Descriptions

Imbricated Rip-rap: A very strong structural revetment constructed from large, rectangular shaped boulders which typically average 2'x3'x4' in size. Boulders are stacked to create walls which protect banks and vegetation. Used in situations to address severe erosion and/or where bank height exceeds 5 feet.

Step Pool Channel: Structure used to address head cuts and/or areas of severe slope. Typically constructed of large boulders similar to those used for imbricated rip-rap.

Root Wads: Natural material revetment constructed of root wads, logs, boulders, and vegetative cuttings designed to protect eroding banks and to provide aquatic habitat. As organic component of revetment deteriorates over time, roots of vegetative cuttings (shrubs)fill voids, thus providing long term stabilization. Can be installed in situations requiring cut, however, this technique is better suited to "fill" applications.

Single and Double Toe Boulders: Natural material revetment constructed from large stone (typically class III) which is stacked one or two high atop a footer boulder which is designed to protect stream banks. Well suited for shade applications, where bank grading is not desirable, and where bank heights are less than 5 feet.

Biologs: A true bioengineering approach which utilizes "logs" constructed of natural coconut fiber which provide bank protection and a rooting medium for both herbaceous and woody plants. Well suited for sunny applications where banks can be graded to provide stable aspects. with low to moderately tall banks (can also be used where tall banks can be graded).

Cross Vanes: A structure constructed of stone which is designed to provide grade control, to locally reduce width-depth ratios, to relieve lateral bank stress, to locally center the thalweg, and to provide in-stream habitat.

Rock Vanes: A structure constructed of stone which is designed to relieve stress from an eroding bank by directing the thalweg channelward, and to provide in-stream habitat. Well suited for use in areas where limited channel capacity may prohibit other revetment techniques.

Bar Sills: Structures constructed of stone which are designed to stabilize, enhance , or create depositional features.

The stream projects are grouped geographically in the list below. Refer to the Implementation Section (Section 5) of the study for recommended construction priority and grouping as individual projects. Wherever possible, the City will construct stream restoration concurrently with any recommended SWM projects for that subwatershed to improve the success of the stream projects.

Project 1

Site 103-1 and 103-2

General Description:
This reach is located immediately downstream of Hurley Avenue and continues to the confluence of this tributary and the main stem of Watts Branch. The channel in this area is generally narrow and incised with moderate to severely eroded banks. The majority of the riparian area is dominated by herbaceous plant communities, therefore, bioengineering techniques are available for use.

Stabilization Techniques:

- Biologs are proposed throughout this reach to address eroded banks. Larger diameter (20") logs are proposed where bank heights are taller than 4 feet. Standard diameter logs (12") are proposed in all other areas. All banks behind the logs are to be graded to 3:1. Seed, vegetative cuttings and biodegradable matting are to be placed on the graded slopes.
- Cross vanes are proposed to maintain existing channel invert elevations.

Access:
Access for construction will be provided from Hurley Avenue. Access pathways follow the channel and for the most part avoid existing trees.

Site 401-15, 401-16, 401-17 and 401-18

General Description:
This project consists of a segment of the mainstem of Watts Branch in the vicinity of the Watts Branch Parkway and Aintree Drive within Woottons Mills Park. The park in this area contains both forested and meadow communities which contain vast areas of potential nontidal wetlands. In general, this system is incised with low width to depth ratios. The channel inverts are in general well below the rooting zone, therefore, there is a significant amount of channel erosion. Where there is ample sunlight penetration, bioengineering techniques are utilized.

Stabilization Techniques:
- Double (stacked) biologs are proposed where there is ample sunlight to support vigorous plant growth. A stacked arrangement is proposed due to the significant bank heights which sometimes exceed 6' in height. As with all biolog applications, slopes behind the revetment should be graded to a 3:1 slope, matted, seeded and planted with vegetative cuttings.
- Double toe boulders are proposed to address bank erosion where there is too much shade to support a bioengineering approach. Grading is recommended behind this revetment to provide for a planting area.
- There is an existing debris blockage and a dilapidated USGS gage station which are impeding bedload transport and are causing lateral stress on the banks. These should be removed as soon as practical. As an alternative, consideration should be given to maintaining the USGS station for potential future use as a monitoring point to assess the effectiveness of upstream management efforts.
- There is an existing, exposed sewer manhole in the center of the stream adjacent to the existing Aintree stormwater pond. This feature is causing lateral stress on the banks, and poses a potential hazard in that it is vulnerable to damage. This feature should be relocated well beyond the limits of the channel.
- Imbricated walls (rip-rap) are proposed in one area where bank heights exceed 6 feet, and erosion is severe and is threatening the loss of trees at the top of the banks.

Access:
Access for construction will be provided from three locations: from Aintree Drive, from the tot-lot at the terminus of Aintree Drive, and from a park entrance off of Watts Branch Parkway. Access pathways follow existing macadam pathways, existing sewer right-of-ways, and open areas (where feasible) to avoid impacts to trees.

Project 2

Site 301-2, 301-3 and 301-4

General Description:
This project consists of a segment of the mainstem of Watts Branch in the vicinity of the intersections of Maryland Route 28, Watts Branch Parkway, and Hurley Avenue. In general, this system has a low sinuosity, is moderately to mostly stable, and offers moderate to good in-stream habitat.

Stabilization Techniques:
- Double toe boulders are proposed to address bank erosion due to a) shade conditions and b) the desire to protect existing trees and root systems. Minor channel adjustments are proposed downstream of Hurley Avenue.
- Cross vanes are proposed to center the thalweg and to maintain existing channel invert elevations.
- There is an existing, exposed gas pipeline located immediately upstream of the Hurley Avenue Bridge. This utility needs to be relocated to a lower elevation. A cross vane is proposed at this location to provide grade control.
- There is an existing mid-channel bar located approximately 400 feet upstream of the Hurley Avenue Bridge which is causing severe lateral stress on the banks. This is to be removed.

Access:
Access for construction will be provided from three locations: from Crofton Hill Lane, Maryland Route 28, and Hurley Avenue. Access pathways exist primarily in open areas, and have been designed to avoid the scattered trees which exist in the riparian areas.

Project 3

Site 401-8, 401-9, 401-10 and 401-11

General Description:
This project consists of a segment of the mainstem of Watts Branch located east of Wootton Parkway within Woottons Mill park, which is entirely forested. In general, this system is mostly stable, but is experiencing severe erosion along two adjacent, tortuous meanders.

Stabilization Techniques:
- Imbricated walls (rip-rap) are proposed in two areas where erosion is severe, and to prevent the channel from migrating over an existing sewer line.
- One small segment of rootwads is proposed along a portion of a meander where the channel is to be adjusted and the thalweg relocated streamward several feet. Rootwads are favored here due to the significant amount of encroachment/fill desired.
- Rock vanes are propose in three locations. Two are proposed within a tortuous meander to direct the thalweg and energy from the banks. The third is located immediately upstream of

a pedestrian bridge at the upstream limit of the project. This is intended to direct energy away from the bank and protect the bridge footer from scour.

Access:
Access for construction will be provided from two locations: from Greenplace Terrace and from Paulsboro Drive. Access pathways follow an existing sewer right-of-way and an existing macadam pathway to avoid impacts to trees.

Project 4

Site 302-3, 302-4, 302-6, 302-8, 115A-1 and 115A-2

General Description:
This project consists of a segment of the main stem of Watts Branch and a first order tributary within Woodley Gardens Park adjacent to Nelson Street. In general, the main stem of Watts Branch in this area is moderately stable with discrete areas of erosion along the outside of meander bends. The unnamed first order tributary is mostly unstable with areas of continuous, significant bank erosion. This system originates from a 48" concrete pipe adjacent to the cul-de-sac at Wilson Avenue which directs energy toward the left bank. In addition, this system is moderately incised in areas which requires consideration of capacity when finalizing rehabilitation designs.

Stabilization Techniques:
- Single and double toe boulders are proposed to address bank erosion on these reaches due to a) shade conditions and b) the desire to protect existing trees and root systems. Single toe boulders are used where bank heights are lower than 3 feet; double toe boulders are used in all other areas. Minor channel relocation is proposed where channel geometry is excessively tortuous.
- Cross vanes are proposed to center the thalweg and to maintain existing channel invert elevations.
- Rock vanes are propose in two locations. These are placed to direct energy away from the banks in areas where bank erosion is moderate and where channel capacity would be compromised by use of a boulder revetment.
- Imbricated walls (rip-rap) are proposed in areas where channel relocation is proposed, and where bank erosion is most severe.
- Existing debris blockages on the first order tributary are causing significant channel alterations and are interfering with bedload transport. These should be removed as soon as possible.
- There is an existing, failed sewer protection feature on the first order tributary which is constructed of grouted stone and is proposed to be removed. A cross vane is proposed downstream of the utility crossing to hold grade in this area.

Access:
Access for construction will be provided from Nelson Street and the park parking area off of Nelson Street. Access pathways will follow the existing macadam path, open areas adjacent to the channel, existing, unimproved pathways, and existing sewer right-of-ways in order to minimize impacts to trees.

Project 5

Site 205-5, 205-6, 205-7 and 205-8

General Description:
This project consists of a segment of a second order tributary which flows through Upper Watts Branch Park downstream of Gude Drive. In general, this system is moderately unstable with discrete areas of erosion along the outside of meanders. The channel has moderate to good access to its floodplain and is moderately tortuous. Channel capacity does not appear to pose a limitation, but still should be considered during the final design process.

Stabilization Techniques:
- Single and double toe boulders are proposed to address bank erosion on these reaches due to a) shade conditions and b) the desire to protect existing trees and root systems. Single toe boulders are used where bank heights are lower than 3 feet; double toe boulders are used in all other areas. Minor channel relocation is proposed where channel geometry is excessively tortuous.
- Cross vanes are proposed to center the thalweg and to maintain existing channel invert elevations.
- A step pool channel is proposed below an existing, eroded stormwater outfall which apparently drains portions of Fordham Street.

Access:
Access for construction will be provided from Fordham Street. Access pathways will follow existing, unimproved pathways through the park and a portion of an existing sewer right-of-way in order to minimize impacts to trees.

Project 6

Site 302-12, 204-1, 205-1 and 205-2

General Description:
This project consists of segments of second and third order streams within Upper Watts Branch Park which is entirely forested. In general, these segments are moderately sinuous, and are unstable with eroded banks along the outside of meanders.

Two storm drain outfalls showing signs of significant erosion along the drainage path between the end of the pipe and the stream channel were also identified and could be stabilized as part of that project. The two outfalls are located, respectively, at the end of Azalea Drive, and east of Aster Boulevard between Azalea Drive and Nelson Street. At the final design stage for the stabilization for stations 204-1 and 302-12, the City should investigate options to stabilize these outfalls, including bioengineering techniques (e.g., boulders and plantings) and extension of the storm drain outfalls. The benefits of stabilizing these outfalls must be weighed against the construction disturbance to the mature trees in the area. The City will need to work with the nearby residents to discuss these issues. The City should measure the existing eroded outfall channels to compare with conditions at the final design stage. If the channel sizes appear to have stabilized, only minor repairs and vegetative stabilization may be needed, which will minimize disturbance.

Stabilization Techniques:
- Single and double toe boulders are proposed to address bank erosion on these reaches due to a) shade conditions and b) the desire to protect existing trees and root systems. Single toe boulders are used where bank heights are lower than 3 feet; double toe boulders are used in all other areas. Minor channel relocation is proposed where channel geometry is excessively tortuous.
- Cross vanes are proposed to maintain existing channel invert elevations.
- One small segment of rootwads is proposed where the channel is to be adjusted and the thalweg relocated streamward several feet. Rootwads are favored here due to the significant amount of encroachment/fill desired.
- A step pool channel is proposed in an existing, high gradient, first order tributary which is currently severely eroded and incised.

Access:
Access for construction will be provided from two locations: The Cul-de-sac at the end of Azalea Drive and from Princeton Place. Access pathways for the most part follow existing, unimproved pathways in order to minimize impacts to trees.

Project 7

Site 401-2, 401-3, 401-5, and 401-6

General Description:
This reach is located on the main stem of Watts Branch immediately downstream of Wootton Parkway. In general, the stream is moderately stable with a tortuous geometry. In-stream habitat is fair to good, with several deep pools which provide excellent fishery habitat. Debris blockages are present which has caused localized channel widening and has disrupted bedload transport.

Stabilization Techniques:
- Bar sills are proposed in a straight reach which is excessively wide. The bar sills are placed in a depositional area and are designed to trap bedload to develop a side bar which will reduce channel width.
- Existing, failed sewer protection features which are constructed of grouted stone are proposed to be removed.
- Debris blockages are to be removed.
- Channel realignment is proposed to establish a stable geometry and to address several hundred linear feet of eroded banks along the outside of the meanders. Root wads and imbricated rip-rap are proposed in these areas to provide bank stability.
- Rock vanes are proposed in three locations. One is proposed upstream of a very large American Sycamore tree; this is intended to direct energy away from the root system. The other area is immediately upstream of the crossing of Scott Drive. These are intended to direct the thalweg and erosive energy from the right bank (looking upstream). The third area is located downstream of Scott Drive and the intention is to direct the thalweg away from the

bank, and to provide protection to the right bank in the area of the downstream-most sewer crossing.

- One cross vane is proposed at the upstream limit of a straight reach. The intended purpose is to enhance in-stream habitat and to alleviate lateral stress on the banks.
- Extensive sediment bars have formed on the concrete flume upstream of the Wootton Parkway bridge (RSAT 401-6), obstructing the bridge's conveyance under high flows. The sediment should be removed. Additionally, a portion of the underlying concrete slab should be removed to re-create a natural baseflow channel upstream of the bridge. This work should be coordinated with the future widening of Wootton Parkway.

Access:
Access for construction will be provided from the Wootton High School parking lot and from Scott Drive. Access pathways will follow existing sewer rights-of-way to minimize impacts to vegetation.

Project 8

Site 204-5

General Description:
This reach is located downstream of Carnation Drive on a second order tributary which flows through Upper Watts Branch Park which is entirely forested. In general, the stream is stable with discrete areas of bank erosion along the outside of meanders.

Stabilization Techniques:

- Single and double toe boulders are proposed to address bank erosion along this reach due to a) shade conditions and b) the desire to protect existing trees and root systems. Single toe boulders are used where bank heights up to 3 feet; double toe boulders are used in all other areas.
- Cross vanes are proposed at cross-over reaches to maintain existing channel invert elevations and to center the thalweg.

Access:
Access for construction will be provided from Carnation Drive. The access pathway follows an existing, unimproved pathway in order to minimize impacts to trees.

Project 9

Site 103-5, 103-6, 103-7 and 103-8

General Description:
This reach is located on a first order tributary downstream of Dundee Road. In general, this reach is moderately unstable and incised throughout with severely eroded banks.

Stabilization Techniques:

- Biologs are proposed in the upper-most portion of this reach to address eroded banks, which will graded to a 3:1 slope, matted, seeded and planted with vegetative cuttings. Biologs are suitable at this location due to low bank heights and the lack of trees in the riparian area.
- Cross vanes are proposed to maintain existing channel invert elevations.
- Double toe boulders are proposed to address minor to moderate bank erosion within forested areas due to a) shade conditions and b) desire to protect existing trees and root systems.
- Rock vanes are proposed in several locations. These are placed to direct energy away from banks in areas where bank erosion is minor to moderate and/or where channel capacity would be compromised by use of a boulder revetment.
- Imbricated walls (rip-rap) are proposed in areas where bank erosion is severe and where bank heights exceed 5 feet.
- A step pool channel is proposed in a straight reach where there is an existing, failing reno mattress.

Access:
Access for construction will be provided from three locations: Dundee Road, Wootton Parkway, and from Feather Rock Drive.

The priority stream rehabilitation and stormwater retrofit sites need to be closely coordinated so each site can benefit from the other. Section 5 presents recommendations on how to integrate these together into the final watershed management plan for Watts Branch.

4.1.5 Recommended Outfall Stabilization Projects

Numerous storm drain outfalls showed signs of significant erosion along the drainage path between the end of the pipe and the nearest stream channel. Two of these outfalls were identified near a stream restoration project already recommended in the study, and could be stabilized as part of that project. The two outfalls are located, respectively, at the end of Azalea Drive, and east of Aster Boulevard between Azalea Drive and Nelson Street. At the final design stage for RSAT stations 204-1 and 302-12, DPW will investigate options, including bioengineering techniques, such as boulders and plantings, and extension of the storm drain outfalls. The benefits of stabilizing these outfalls must be weighed against the construction disturbance to the mature trees in the area. DPW will work with the Neighborhood Resource Coordinator to discuss these issues with nearby residents.

DPW will also measure the existing eroded channels to compare with conditions at the final design stage. If the channel sizes appear to have stabilized, only minor repairs and vegetative stabilization may be needed, which will minimize disturbance.

Other storm drain outfalls are in need of repair and stabilization. As DPW surveys each stream reach at final design, outfalls in need of significant repair will be included in the proposed work.

4.2 Wetland Management Plan

A wetland management plan was developed to identify existing wetland areas where a functional improvement can be achieved through enhancement or restoration of existing conditions. Enhancement and creation opportunities identified in the plan relied on findings and observations from stormwater management retrofit and stream rehabilitation assessments, where opportunities for improving wetland function and other subwatershed conditions through wetland restoration and/or creation were presented. Candidate locations for improvement were selected based on the following criteria:

- RSAT and other field assessment recommendations for the location of wetland enhancement and creation;
- Proximity to intermittent and perennial stream channels (isolated wetland enhancement and creation opportunities were not considered due to marginal stream improvement potential);
- Potential for significant water quality improvement (the planting of trees and shrubs to enhance emergent wetlands was not recommended because thermal loading is not an issue in the Watts Branch Watershed);
- Location within hydric soil areas (NRCS Soil Survey for Montgomery County);
- Low lying, flat areas where grading work will be minimal;
- Non-forested areas (enhancement of forested wetlands and the clearing of upland forest for the creation of wetlands are not practical methods for improving water quality).

A description of each wetland improvement area including existing conditions, property ownership, enhancement/creation approach, and possible water quality benefits is provided below. Figure 4.2 shows the general location of the improvement areas. A full-sized plan map has been prepared using a variety of data sources including: hydric soil boundaries (from the NRCS Soil Survey for Montgomery County) and existing wetland areas (from the U.S. Fish and Wildlife Service National Wetland Inventory Map/Rockville Quadrant). The full-sized map is not included as part of this report, but has been provided to the City as part of the project record.

Wetland Improvement Area Descriptions

Area #1 This is a privately owned, open area adjacent to a small, perennial tributary of Watts Branch. The site abuts retrofit site SM-18 and is surrounded by a thin forested edge. Portions of this proposed area could be graded in conjunction with site SM-18 construction to increase floodplain storage and, where there are existing herbaceous wetlands, enhanced with native wetland trees and shrubs.

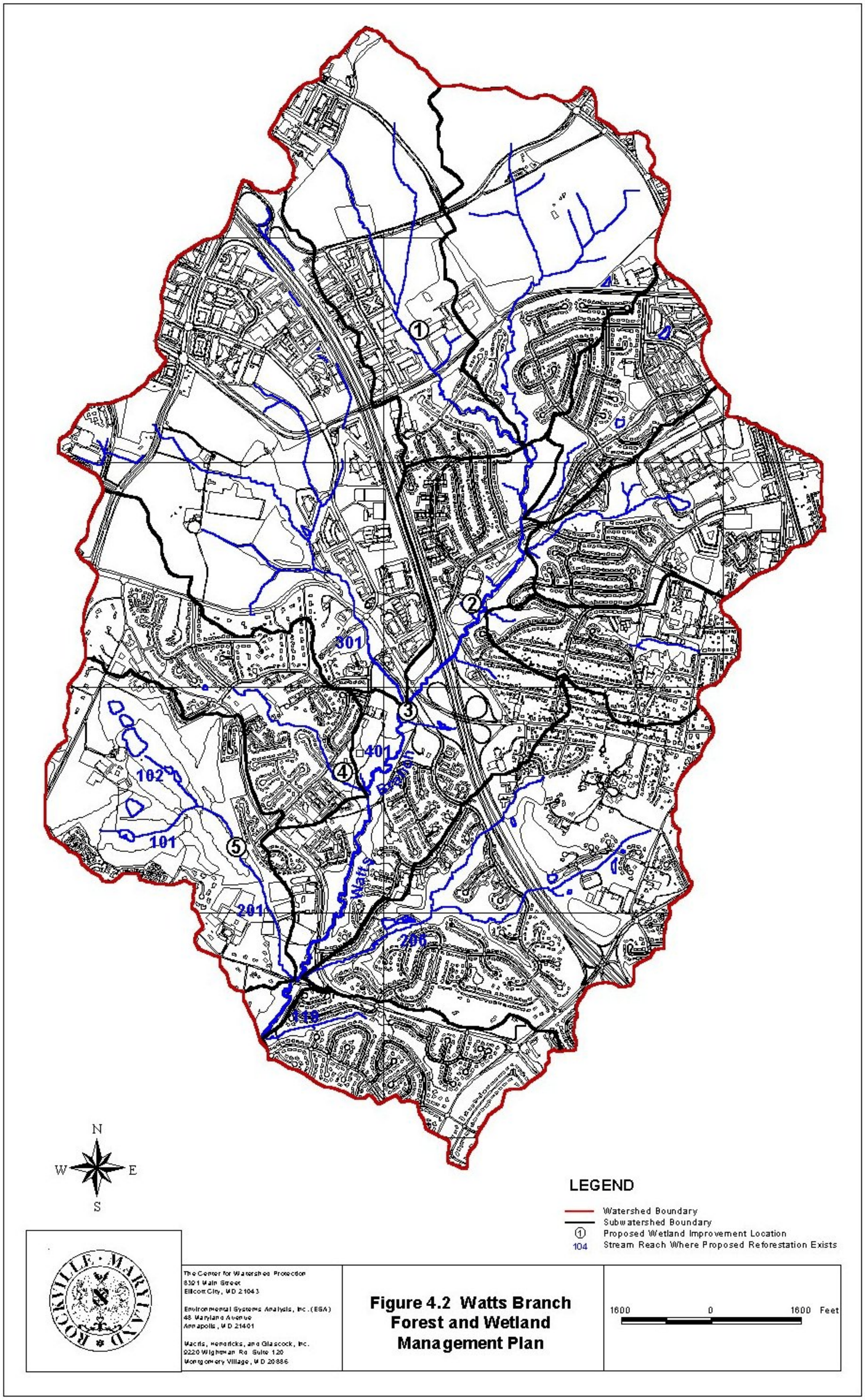
Area # 2 This site is located in Woodley Gardens Park and consists of a drainage ditch/swale with emergent wetland vegetation. This ditch drains an adjacent ballfield and, during storm events, it transports pollutants associated with turf maintenance (mainly fertilizer and pesticides) as well as some sediment. This swale should be enlarged as much as possible and the gradient should be reduced so that it can retain greater volumes of storm water. This will lessen pollutant flows to the receiving stream and lower peak flows. Native wetland plants and shrubs should be planted in the expanded ditch to maximize pollutant uptake. In addition, trees can be planted adjacent to the newly graded area to improve wildlife habitat and the overall aesthetic of the park.

Area # 3 This is an existing emergent wetland located at the northern end of Woottons Mill Park (public property). During storm events, an eroding channel carries overflow and sediment from the wetland into the adjacent stream. If this erosion is not checked, it will continue to pollute the stream and it could eventually drain the wetland. To preserve the wetland and improve water quality, the channel should be filled and stabilized. If necessary, grading work should be performed to lessen concentrated flows to the stream during storm events, thereby eliminating future channelization and erosion. Expansion of the existing wetland is also possible during the grading operation and is strongly recommended. The increase would provide greater storage capacity during storm events. Whether this wetland is an emergent, scrub shrub or a forested system is not critical. However, a forested system would be more in keeping with the natural wetland systems within the Watts Branch watershed.

Area # 4 This is an open area located at the southwestern tip of Woottons Mill Park. Its low elevation when compared to the adjacent stream makes it an excellent candidate for wetland creation. With minimal grading, this site can provide increased floodplain access for the stream thereby reducing sediment loads and erosive velocities during storm events. A forested wetland system would be more appropriate for this site and, therefore, woody wetland trees and shrubs are recommended.

Area # 5 This site consists of the open, low lying areas adjacent to the Watts Branch tributary which bisects the Lakewood Country Club golf course (private property). Run-off from the golf course can contain nutrients and pesticides. These pollutants can be filtered by enhancing the existing emergent wetlands and creating additional wetlands. Wetland enhancement can be accomplished by planting native wetland shrubs and trees for greater nutrient uptake. The development of a tree canopy will also reduce thermal loading. Wetland creation can be accomplished by performing minor grading to capture run-off before it enters the stream. These areas can then be planted with herbaceous or woody wetland species. A dense ground layer would be most desirable in these areas to slow the flow of water and to filter out suspended solids.

Figure 4.2 Wetland Improvement and Reforestation Management Plan



4.3 Forest Management Plan

A forest management plan has been prepared for the Watts Branch watershed in order to identify and enhance specific areas within the riparian corridor. Specifically, the plan targeted areas within 150 feet of perennial/intermittent streams to indicate gaps in the stream valley corridor greater than 1/4 acre. These criteria were established to ensure that the proposed forest areas would be large enough to be ecologically sustainable and wide enough to serve as an effective biological filter for water quality while not overextending the City's financial and human resources.

Open areas and 150 foot buffers were initially identified using a base map showing Watts Branch and its tributaries, the large forested tracts within the watershed (taken from the 1993 M-NCPPC GIS Land Use/Land Cover Map for Montgomery County), and the existing tree cover in the City of Rockville's parks (1999 City of Rockville Parks & Recreation Department survey). Reforestation recommendations were modified by removing areas slated for current or future development. Next, aerial photographs were used to identify playing fields, buildings, or other facilities within the recommended areas which would preclude their use. The aerial photographs were also used to identify any forest cover discrepancies on the base map. Finally, the RSAT data sheets for the entire watershed were reviewed to ensure that no reforestation opportunities were overlooked on the map and to eliminate any reforestation locations due to conflicting uses not apparent from the aerial photographs. The data sheets were also used to develop management recommendations (e.g., the presence of invasive species) and to compile the reforestation species recommendation list.

Public property reforestation opportunities have been separated from private opportunities. Public and private properties were identified using tax maps and the 1999 ADC map for Montgomery County. A summary of the private and public reforestation acreage within each Watts Branch tributary and specific management recommendations are provided in Table 4.8. Figure 4.2 shows the general locations of these areas. A full-sized plan map has been prepared but is not included as part of this report. The City has a copy of the map as part of the project record.

Reforestation/ afforestation plans are subject to approval by the City Forester. Location and spacing of trees, species selection and planting details must be included in an approved Forest Conservation Plan.

Table 4.8 Summary of Recommended Reforestation Sites

Stream Reach	Total Reforestation Acreage	Private Acreage	Public Acreage	General Notes
401	11.5	0.3	11.2	Mile-a-minute and Multiflora Rose management suggested.
119	3.4	3.4	-	-
206	7.9	-	7.9	-
201/101/102	6.5	4.2	2.3	Tall fescue and Multiflora rose management suggested.
301	4.8	4.8	-	-

Reforestation Species Recommendations

Based on the RSAT vegetation data and Brush, Lenk, and Smith's vegetation map of Maryland (G.S. Brush, C. Lenk, J. Smith, 1980. *The Natural Forests of Maryland: An Explanation of the Vegetation Map of Maryland*. Ecological Monographs), the stream valley forests in the Watts Branch watershed belong to the "Sycamore-Green Ash-Box Elder-Silver Maple" association. Other typical species in this association include: Red Maple (*Acer rubrum*), White Oak (*Quercus alba*), Flowering Dogwood (*Cornus florida*), Black Cherry (*Prunus serotina*), Northern Red Oak (*Quercus rubra*), Spicebush (*Lindera benzoin*), Tulip Poplar (*Liriodendron tulipifera*), Black Gum (*Nyssa sylvatica*), Sassafras (*Sassafras albidum*), White Ash (*Fraxinus americana*), Arrowwood (*Viburnum dentatum*), Black Oak (*Quercus velutina*), and Ironwood (*Ostrya virginiana*). A preliminary reforestation species list was compiled using a combination of typical "Sycamore-Green Ash-Box Elder-Silver Maple" association species and "RSAT" species. This list was then edited based on the following factors: nursery availability (some species are not even propagated); disease resistence; drought resistence; and light tolerance (some species can not handle the full sun exposure that reforestation areas are subject to). The final list is provided in Table 4.9. Species denoted with an asterisk (*) are dominant species. Each reforestation area should contain at least three dominant species and dominant species should make up 60 to 75% of the reforestation planting.

Table 4.9 Reforestation Species Recommendations

COMMON NAME	SCIENTIFIC NAME
Trees	
Box Elder*	*Acer negundo*
Silver Maple*	*Acer saccharinum*
Red Maple*	*Acer rubrum*
Birch	*Betula nigra*
Green Ash*	*Fraxinus pennsylvanica*
Sweet Gum	*Liquidambar styraciflua*
Tulip Poplar*	*Liriodendron tulipifera*
Black Gum	*Nyssa sylvatica*
American Sycamore*	*Platanus occidentalis*
White Oak	*Quercus alba*
Pin Oak	*Quercus palustris*
Northern Red Oak	*Quercus rubra*
Black Willow	*Salix nigra*
Understory & Shrubs & Vines	
Flowering Dogwood	*Cornus florida*
Persimmon	*Diospyros virginiana*
American Holly	*Ilex opaca*
Witchhazel	*Hamamelis virginiana*
Spicebush	*Lindera benzoin*
Arrowwood Viburnum	*Viburnum dentatum*
Black Haw	*Viburnum prunifolium*

* Dominant Species

Planting Recommendations

- **Size -** In general, planting should be performed using containerized plant material. Containers should be no less than 2 gallons and no greater than 5 gallons. Container stock smaller than 2 gallons can be easily overlooked by maintenance personnel and accidentally mowed. In addition, small stock is a desirable food source for deer. Plant stock larger than 5 gallons is expensive and often requires a much longer time to adapt to field conditions, meaning higher initial maintenance. Balled and burlapped (B&B) stock is not recommended due to the significant loss of root mass during the removal operation.

- **Planting Density/Spacing -** One to three gallon container plants should be installed at a rate of 350 per acre. Five gallon container plants should be installed at a rate of 200 per acre. These are the densities recommended in the State Forest Conservation Manual. Spacing between plants should be varied to lend a natural appearance to the reforestation area. Minimum spacing between shrubs should be 3 feet. Minimum spacing between trees should be 6 feet.

- **Site Preparation -** Reforestation areas should be free of all noxious, invasive, and allelopathic species prior to planting. The primary target species are: Multiflora Rose (*Rosa multiflora*), Japanese Honeysuckle (*Lonicera japonica*), Asiatic Bittersweet (*Celastrus orbiculatus*), Porcelain Berry (*Ampelopsis brevipedunculata*), Japanese Knotweed (*Polygonum cuspidatum*), Mile-a Minute (*Polygonum perfoliatum*), and K-31 Tall Fescue (*Fesctuca arundinacea*). Control of these species should be accomplished through physical and/or chemical means.

  Where reforestation is proposed for an area that is maintained as lawn, it is strongly recommended that the grass be sprayed with a non-selective herbicide such as "Round-up". After the grass has died, the reforestation trees and shrubs may be planted. Finally, a mulch of 3" to 4" of leaves (the use of leaves collected from residences may be used) should be spread over the entire reforestation area to prevent the regrowth of grass and to provide a natural bed of organic matter. The grass **should not** be physically removed because its roots will hold the soil until the trees and shrubs become established.

  Reforestation areas that are not maintained as lawn but are dominated by a natural grassland community require special attention to prevent damage by voles and other rodents which eat bark and can girdle the trees. Since these rodents prefer feeding in areas where they are hidden by vegetation, it is essential to keep the grasses away from the trunks of the trees. This can be accomplished by mulching the base of the tree as recommended under "Planting Procedure" below and by periodically spraying a non-selective herbicide on weeds and grasses that grow within the mulch ring. Mowing of natural grassland communities to accomplish this control is not recommended.

- **Planting Procedure -** Planting should be conducted in accordance with the latest issue of the Landscape Contractors Association MD-DC-VA *Landscape Specification Guidelines* and as follows: backfill should consist of 1/4 organic matter ("Leafgro" or "Compro") and 3/4 existing soil; fertilizer should not be used unless organic matter backfill is unavailable; a 3" deep, 3 foot diameter mulch ring shall be placed around each tree. Any vegetation within the mulch ring should sprayed with an herbicide prior to the application of the mulch and allowed to work before placing the mulch. Mulch shall be aged, hardwood mulch, dark brown in color, uniform in size and free of foreign matter.

Management Recommendations

- **Watering -** Periodic watering of reforestation plant material is essential during the first year or two after planting. This will ensure that the root system is sufficiently developed to sustain the plant during periods of drought. At least one watering every month from May to September is recommended. This schedule may need to be adjusted depending on weather conditions.

- **Invasive Control -** All reforestation areas should be periodically inspected (once or twice each year) for invasive exotic species that can rapidly outcompete young trees and shrubs (see "Site Preparation" for the most common species). Identified species should be removed using physical and/or chemical means.

- **Predation Control -** Where buck rub and rodent problems are severe, collars or sleeves can be placed around the tree trunks. These devices are generally made of plastic and there are a number of different designs. The best design depends on the size of the tree and the type of predation. Please note that these collars/sleeves are not the "tree tubes" that are sold for use with seedlings.

- **Access Control -** Careful thought should be given to the location of reforestation areas where pedestrian traffic is high. Pathways, even if those paths are not formally recognized, should not be blocked by a reforestation area or it will be vandalized. Where reforestation areas are located adjacent to high traffic areas and highly maintained areas, they should be protected by fencing. This will prevent the creation of new pedestrian paths through the reforestation area, lessen (but not eliminate) the chances of vandalism, and prevent lawn maintenance personnel from accidentally mowing these areas - signs, alone, are not a deterrent. Fencing can be permanent or temporary depending on the setting. Temporary fencing does not usually last more than a year, especially in high use areas where vandals will tear it down. Periodic repair will have to be figured into the cost. Fencing should remain for at least one year and probably two or three to ensure the establishment of the reforestation area. Permanent fencing is preferable, but is more expensive.